

1 **REFLECTOR PLATES FOR A REFLECTIVE LIQUID CRYSTAL**

2 **DISPLAY AND METHODS FOR FABRICATING THE SAME**

3 BACKGROUND OF THE INVENTION

4 1. Field of the Invention

5 The present invention relates to reflector plates for a reflective liquid
6 crystal display and methods for fabricating the same, in particular to a method for
7 fabricating reflector plates that can prevent light reflections from the exposure
8 stage during the formation of undulating resin outgrowth, in order to avoid
9 abnormal patterns occurring on the reflective surface, and furthermore the
10 present invention can also shorten the exposure time and increase production
11 yield.

12 2. Description of Related Arts

13 Reflective liquid crystal displays in general employ an external light
14 source to illuminate display images. This new type of reflective display can
15 effectively reduce the need of using a back light source and can achieve
16 considerable saving on power consumption, making it suitable for portable
17 applications.

18 Reflective displays in general have a reflector plate on the display panel,
19 replacing the conventional back-light portion. These reflector plates can be
20 further classified into a full reflective type and a semi-transmissive type. The
21 reflective type reflector plate is usually equipped with a front-light module which
22 is used to supplement external light for the necessary illumination on a liquid
23 crystal display. The semi-transmissive type reflector plate, like a half-mirror, is
24 able to receive light from a back-light module in supplement of external light

1 when the ambient light is insufficient. However, display devices having either the
2 reflective type or the semi-transmissive type reflector plate do not need the
3 front-light or back-light illumination in the normal conditions, so their power
4 consumption can be reduced. As mentioned earlier, the reflective display having
5 a reflective type reflector plate is usually equipped with a front-light module.
6 When the external light is insufficient, the display device can switch to the
7 front-light module to supplement the ambient light. However, the above-
8 mentioned reflective light technology has the shortcoming of noise signals and
9 this is yet to be solved. As a result, the semi-transmissive type reflector plate is
10 more favored by users. The semi-transmissive type reflector plate is able to use a
11 back light to supplement the ambient light. This is implemented by creation of an
12 undulating resin outgrowth on the reflective surface of the reflector plate.

13 Fig. 7 shows the steps for fabricating a semi-transmissive type reflector
14 plate. A glass substrate (70) is prepared with thin film transistors built on top; and,
15 a layer of transparent electrical conductor such as indium-tin-oxide (ITO) is
16 deposited over the surface. Since the glass substrate (70) has thin film transistors
17 formed in advance of the transparent electrodes, a pixel region is formed in
18 between the glass substrate (70) and the transparent electrodes (71) with a gate
19 insulating layer (701) and a protection layer (702).

20 The transparent electrodes (71) are formed by spin coating a layer
21 polymer resin on the surface to form a photo-resist layer (72); then the photo-
22 resist layer is exposed to light in a lithography process to remove photo-resist in
23 areas other than the pattern areas to create a photomask as shown in Fig. 7b; then
24 a metal layer as shown in Fig. 7c, is deposited on the surface to create a reflective

1 film (73); the metal deposits in the non-pattern areas are removed after photo-
2 etching to form a light transmitting region (74), thus completing the formation of
3 a reflective type reflector plate with undulating resin outgrowth.

4 The reflective film (73) can be a single layer or multiple layers of film. In
5 the case of a 3-layer film, the materials used in different layers are molybdenum
6 alloy (Mo), aluminum (Al), and molybdenum alloy (Mo) in that order.

7 Figs. 8a~c shows the process of fabricating a reflective type reflector
8 plate, in which the basic steps are similar to those used for a semi-transmissive
9 type reflector plate, except that the step to create the light-transmitting region is
10 not necessary for the reflective type reflector plate.

11 In the fabrication of the reflective type reflector plate mentioned above,
12 it is necessary to point out that the process for fabricating the undulating resin
13 outgrowth over the reflective surface will significantly affect the yield rate and
14 the defect rate in the production of these reflector plates.

15 In detailed analysis of the fabrication process, the glass substrate (70) is
16 placed on the exposure stage, and the photomask is precision aligned and fixed
17 over the light projection areas of the exposure stage, a vacuum pad is then
18 adhered to the bottom of the glass substrate (70) for firming the substrate, and the
19 photo-resist layer is spin coated on the surface of the glass substrate (70) and
20 exposed under light. In the process, the vacuum pad and the protrusion pins will
21 cause light reflection from the exposure stage, leading to some undesired pattern
22 marks on the surface due to uneven exposure of the photo-resist layer. The
23 pattern marks still exist in a subsequent fabrication process of the reflective film
24 (73). The pattern marks reflecting the shapes of the vacuum pad and the

1 protrusion pins will be developed on the reflective film (73), thus seriously
2 affecting the yield in the production of the reflector plates.

3 The problem of reflections from the exposure stage which will affect the
4 yield rate of reflector plate output will have to be corrected.

5 **SUMMARY OF THE INVENTION**

6 The main object of the present invention is to provide a method for
7 fabricating reflector plates of a reflective liquid crystal display that can prevent
8 abnormal reflection from the exposure stage during the formation of the
9 undulating resin outgrowth, thus it can prevent abnormal pattern marks occurring
10 over the reflective surface, shorten the exposure time in the lithography process
11 and improve the yield rate in the production of reflector plates.

12 The method for fabricating reflector plates of a reflective liquid crystal
13 display comprises the steps of:

14 forming transparent electrodes after thin film transistors are built on top
15 of a glass substrate;

16 depositing a protection layer over the transparent electrodes for shielding
17 off light reflection from the exposure stage;

18 patterning the transparent electrodes and the protection layer to define
19 the pixel grid through the steps of:

20 spin coating a photo-resist layer over the protection layer with polymer
21 resin material;

22 removing resin materials in non-pattern areas of the photo-resist layer by
23 light exposure and developing with a developing solution; and

24 depositing a reflective film over the polymer resin.

1 In the above-mentioned fabrication process, the protection layer is
2 created in advance of the undulating resin outgrowth; therefore it can effectively
3 prevent reflection from the exposure stage that causes abnormal pattern marks on
4 the reflective surface due to uneven exposure. The above-mentioned fabrication
5 process applies to a reflective type reflector plate.

6 In the case of a semi-transmissive type reflector plate, after finishing the
7 reflective film, there should be a photo etching process to remove the metal
8 deposits over non-pattern areas to form a light-transmitting region on the
9 reflective film.

10 The secondary object of the present invention is to create a protection
11 layer in the pixel region at the same time as the formation of the thin film
12 transistors on the glass substrate, so as to shield off reflection from the exposure
13 stage during the lithography process and the development of uneven reflective
14 surface.

15 The features and structure of the present invention will be more clearly
16 understood when taken in conjunction with the accompanying drawings.

17 **BRIEF DESCRIPTION OF THE DRAWINGS**

18 Figs. 1a ~d are the fabrication process of a reflective type reflector plate
19 as implemented in the first embodiment;

20 Figs. 2a ~d are the fabrication process of a semi-transmissive type
21 reflector plate as implemented in the second embodiment;

22 Fig. 3 a ~c are the fabrication process of a reflective type reflector plate
23 as implemented in the third embodiment;

24 Figs. 4a ~c are the fabrication process of a semi-transmissive type

1 reflector plate as implemented in the fourth embodiment;

2 Figs. 5a ~c are the fabrication process of a reflective type reflector plate
3 as implemented in the fifth embodiment;

4 Figs. 6a ~c are the fabrication process of a semi-transmissive type
5 reflector plate as implemented in the sixth embodiment;

6 Figs. 7a ~c are the conventional fabrication process for a semi-
7 transmissive type reflector plate of display device; and

8 Figs. 8a ~c are the conventional fabrication process of a reflective type
9 reflector plate of display device.

10 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

11 The present invention will hereinafter be described in reference to the six
12 embodiments and the drawings. The fabrication process includes the steps of:

13 forming transparent electrodes after thin film transistors are built on top
14 of a glass substrate;

15 depositing a protection layer over the transparent electrodes for shielding
16 off light reflection from the exposure stage;

17 patterning the transparent electrodes and the protection layer to define
18 the pixel grid, which is performed through a series of processes:

19 spin coating a photo-resist layer over the protection layer;

20 removing the resin materials in the non-pattern areas of the photo-resist
21 layer by light exposure and development; and

22 depositing a single or multiple layer reflective metal film.

23 This fabrication process starts with the pre-formation of a protection
24 layer on the glass substrate in advance of the undulating resin outgrowth, thus

1 enabling effective shielding of reflection from the exposure stage during
2 lithography, which results in abnormal pattern marks occurring on the reflective
3 surface due to uneven exposure.

4 The formation of transparent electrodes (11), as shown in Fig. 1A, it is
5 performed after thin film transistors are built on top of a glass substrate (10), so
6 that a pixel region is formed in between the glass substrate (10) and the
7 transparent electrodes (11) have a gate insulating layer (101) and a protective
8 layer (102).

9 The forming of a protection layer (12), metal or non-metal, as shown in
10 Fig. 1b, on the surface of the transparent electrodes (11) to shield off light
11 reflection from the exposure stage during lithography. In the present embodiment
12 the metal material used in the process is molybdenum alloy, or could be other
13 metals such as AL, Cr, Cu, Co, Mo, Ti, W, Sn, Pb, Ag, Au, Ni, or Zr.

14 The patterning of the transparent electrodes (11) and the protection layer
15 (12) is performed through the process of spin coating of the photo resist layer (13)
16 over the protection layer (12) using polymer resin material, as shown in Fig. 1c;
17 exposure with a photomask and development with a development solution to
18 remove the resin material over the non-pattern areas.

19 The deposition of a single or multiple layers of reflective metal film (14)
20 as shown in Fig. 1d, is in accordance with the masked pattern. In the present
21 embodiment, the reflective metal film (14) is formed by a three-layer film
22 structure, composed of Molybdenum alloy, aluminum, and then Molybdenum
23 alloy:

24 Figs. 2a~c show the fabrication process to produce a semi-transmissive

1 type reflector plate. The basic steps are identical to those used for the reflective
2 type reflector plate, including deposition of the transparent electrodes, patterning
3 the transparent electrodes and the protection layer, deposition of a photo-resist
4 layer, exposure and development, and deposition of the reflective metal film, as
5 shown in Figs. 2a~c. However, in order to achieve partial light transmission
6 through the reflector plate, there is an etching back process after the deposition of
7 the reflective metal film, as shown in Fig. 2d, to remove some of the metal
8 deposits on the protection layer (12) to create a light-transmitting region (15).

9 The present invention as it applies to the fabrication reflective type
10 reflector plate and semi-transmissive type reflector plates in several of the
11 preferred embodiments is more advantageous over the conventional method,
12 which will be explained below:

13 Prevention of abnormal pattern marks occurring on the reflective surface:
14 the protection layer enables light projections to be scattered evenly over the
15 reflection surface of the protection layer, not in the regular reflection direction.

16 Since the protection layer (12) is created in advance of the undulating resin
17 outgrowth, the protection layer (12) can effectively shield off the reflections from
18 the exposure stage, thus no image of the vacuum pad and the protruding pins will
19 appear on the reflective surface, thus there will be no abnormal pattern marks on
20 the reflective surface, and the yield rate of the reflector plate can also be
21 improved.

22 Shortening the exposure time during lithography: the conventional
23 processes use polymer resin material with low photosensitivity and thick body.
24 The low photosensitivity resin could prolong the exposure time, and the thick

1 body resin could cause uneven light exposure. However, in the present invention,
2 highly photosensitive resin is used to shorten the exposure time, and the
3 protection layer enables light projections to be scattered evenly over the surface
4 of the protection layer, thus the necessary exposure time of the polymer resin can
5 be shortened. For undulating resin without the protection layer, the light exposure time
6 duration is about 120 mJ, but with the protection layer the light exposure time
7 duration only takes 60 mJ. The light exposure time is shortened by as much as
8 50%, thus improving the output yield.

9 The present invention can be implemented with other fabrication
10 processes besides those disclosed in the embodiments above:

11 Fig. 3 shows the fabrication process of a reflective type reflector plate as
12 implemented in the third embodiment, which enables the reflective film to be
13 formed at the same time as the thin film transistors over the glass substrate (10).
14 Then, an undulating resin outgrowth is built over the reflective film.

15 The thin film transistors are first created on the glass substrate (10), then
16 the gate electrodes, the gate insulating layer, and the protective layer are formed
17 in that order. In the present embodiment, the protection layer in the pixel region is
18 formed at the same time as the formation of the gate electrodes, through unified
19 patterning for the metal interlayers, in the process of forming the thin film
20 transistors . The advantages are that all the characteristics in the previous
21 embodiment can be retained.

22 Fig. 3a shows the fabrication process of a full reflector plate as
23 implemented in the third embodiment. During the formation of thin film
24 transistors on the glass substrate (10), a protection layer (12) is formed at the

1 same time as the gate insulating layer (101) in the pixel region. Then, the
2 sequence of steps, as shown in Figs. 3a~c, are performed over the glass substrate
3 (10): deposition of the transparent electrodes, patterning of the transparent
4 electrodes, deposition of the photo-resist layer, exposure and development, and
5 deposition of the reflective metal film, to complete the fabrication of a full
6 reflector plate.

7 Fig. 4 shows the fabrication process of semi-transmissive type reflector
8 plate in the fourth embodiment, which is basically identical to that of the third
9 embodiment, with the addition of an etching back process to create the light-
10 transmitting region.

11 Fig. 5 shows the fabrication process for a transmissive type reflector
12 plate in the fifth embodiment. The process steps largely resemble those used in
13 the third and fourth embodiments in that the part of protection layer is formed at
14 the same time as the thin film transistors, but the difference is that the
15 source/drain electrodes and the protection layer are formed at the same time in
16 the process of forming the thin film transistors through unified patterning. It can
17 be seen, from Fig. 5a, after the thin film transistors are built on top of the glass
18 substrate (10), a protection layer (12) is formed at the same time as the gate
19 electrodes in between the gate insulating layer (101) and the protection layer (102)
20 the protection layer (12). Subsequent steps in the fabrication process, as shown in
21 Figs. 5a~c, are to be performed over the glass substrate (10) in the order of:
22 deposition of the transparent electrodes, patterning of the transparent electrodes,
23 spin coating of the photo-resist layer, exposure and development, and deposition
24 of the reflective metal film. This process is for fabrication of a full reflector plate.

1 Fig. 6 shows the fabrication process for a semi-transmissive type
2 reflector plate in the sixth embodiment, wherein the only difference in the
3 fabrication process versus the fifth embodiment is the addition of an etching back
4 process to form the light-transmitting region.

5 The foregoing description of the preferred embodiments of the present
6 invention is intended to be illustrative only and, under no circumstances, should
7 the scope of the present invention be so restricted.